



IN THE UNITED STATES PATENT & TRADEMARK OFFICE  
Before the Primary Examiner

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re Application of:

James R. Kahn, et al.

Group Art Unit: 1745

Serial No. 09/766,069

Filed: January 19, 2001

Examiner: J. A. Mercado

For: APPARATUS FOR SPUTTER DEPOSITION

Attorney Docket No. 353-05

DECLARATION OF HAROLD R. KAUFMAN

HAROLD R. KAUFMAN, being duly sworn, deposes and states as follows:

1. I am one of the named inventors in the above-identified application.

2. I have read the office action mailed October 3, 2002 and the references cited by the Examiner.

3. (a) The curved target surface which is referred to in claims 1-3 of this application is for the purpose of enhancing or reducing the arrival of energetic electrons at different locations on a substrate or with different substrates. This concept is described in the specification, p. 16, line 24 to p. 17, line 19.

(b) The Examiner cites Fu, et al. Fu teaches a sloped, contoured, or curved target surface to control target sputtering in an apparatus where a plasma is generated throughout the vacuum chamber. The Examiner has concluded that this prior art makes obvious the use of a curved surface to control the trajectories of secondary electrons (not mentioned in Fu) in an apparatus where the ions are generated in a separate volume at higher pressure. To one well skilled in the sputtering art, this is not

a credible conclusion.

4. The magnetic field thickness  $T$  is described in the specification p. 18, line 2, to p. 19, line 10, and is illustrated in Fig. 5. The specification describes the concept of a magnetic field and the quantitative strength and thickness necessary for containing secondary electrons generated by the ion efflux striking the target.

5. Regarding claim 16, paragraph (d), the concept of adjusting the magnitude of the ion efflux and the magnitude of the bias of the target to assure unstable operation of the secondary electron beam is described in the specification at p. 6, line 9, to p. 7, line 9, and p. 14, line 21, to p. 16, line 20. Thus, when the electrons striking the substrate cause detrimental effects, it can be desirable to operate the apparatus at conditions resulting in electron beam instability so that the electron beam is scattered broadly.

6. In each apparatus described by Ceasar, et al., (the '688 patent) and King (the '751 patent), the ion energy for sputtering a material is provided by the acceleration from the ion source - not from biasing the target negative relative to ground. See Ceasar, et al., col. 4, lines 18-23 and King col. 2, lines 43-49. This means that with the apparatus of either Ceasar, et al., or King the ions leaving the ion source have sufficient energy to sputter adjacent hardware. Consequently, the ion beam must be focused or otherwise directed only at the target in order to prevent the deposited film from being contaminated with sputtered

material from adjacent hardware. Ceasar, et al., use a shield and a collimated ion beam (see col. 7, lines 37-52) to avoid contamination in the deposited film. King shows both a lens 2 and an aperture 3 in his Fig. 2 (see also col. 5, lines 37-40) to achieve focusing on the target. These high energy sputtering processes are similar to the prior art description in the present application, p. 2, line 15, to p. 4, line 17.

7. In the present application, it is not necessary to focus, collimate, or otherwise restrict the ion beam to the target because the ions have an energy of about 50 eV or less. The target must be biased negative relative to ground for significant sputtering to take place.

8. (a) Although Ceasar, et al., refer to ion energies from 0 to 2000 eV (col. 4, lines 26-29), the lower end of this range is obviously spurious to a careful reader. In the same sentence, Ceasar, et al., refer to a spread of ion energy of 1 to 2 eV. With this spread, it is evident to any careful reader that an ion beam with an energy of 0 eV must also and identically have an ion current of 0 A. The examples of ion energy all contradict anything near 0 eV; see col. 6, lines 31-33; see col. 7, line 67, to col. 8, line 2; see col. 8, lines 33-36. The mistakes made by Ceasar, et al., are not restricted to ion energy. They refer to "a Kaufmann [sic] type ion source" (that is, one source, not two) in the description of col. 5, lines 42-55. Yet their Fig. 1 is clearly of the type shown in Figs. 3 and 4 of an article by Kaufman, et al., in the AIAA Journal, Vol. 15, beginning on p.

843 (1977), while their Fig. 2 is clearly a variation more related to that shown in Fig. 1 of an article by Isaacson, et al., in *Journal of Spacecraft and Rockets*, Vol. 14, beginning on p. 469 (1977). Ceasar, et al., also refer to "The potential between the anode and the cathode filament is variable and of the order of from about 50 to about 2000 volts." (See col. 6, lines 1-4.) I have worked in ion sources of this general type since about 1959 and have never heard of a anode to cathode filament voltage over 100 volts, let alone 2000 volts. It is clear that Ceasar, et al., here confused the anode to cathode filament voltage of about 50 volts with the anode to ground potential difference, which can be up to 2000 volts. In short, the examiner has accepted a spurious and false number in ion energy that is part of a pattern of sloppiness by Ceasar, et al.

(b) The preceding all deals with what should be apparent to a careful reader. The lower end of the ion energy range of from 0 to 2000 eV (col. 4, lines 26-29) is also obviously wrong to anyone skilled in the art of Kaufman type ion sources. Starting with U.S. Patent 3,156,090 Kaufman, the energy range is given as one kev to several kev (see col. 4, lines 19-22). As the inventor, I can state with absolute certainty that the range in the Kaufman patent was not one ev to several kev, as the Examiner has chosen to interpret it elsewhere. A chapter by Harper in a book, *Thin Film Processes* (edited by Vossen and Kern), Academic Press, New York (1978), beginning on p. 175, gives the energy range for a Kaufman ion source as 500-2000 ev (p. 181 therein).

There is no substantive reference that the Examiner has given for an energy even approaching 50 eV. In addition I have personally tested the type of ion source described by Ceasar, et al., and can state positively that they could not have operated their source and generated an ion beam of 50 eV or less.

(c) In summary regarding the 0-2000 eV energy range from Ceasar, et al., the Examiner has capriciously chosen a number that is wrong, as would be noted either from a careful reading of Ceasar, et al., or from the statement of one skilled in the art. The apparatus of Ceasar, et al., requires acceleration of the ions to take place in the ion source, and a high ion current cannot be obtained in an ion source using electrostatic acceleration without the use of high voltage.

9. I am the inventor of the Kaufman ion source, as described in U.S. Patent 3,156,090. The only ion source mentioned by Ceasar, et al., is a Kaufmann [sic] source (col. 5, lines 43 and 47). The Kaufmann [sic] ion source described by Ceasar, et al., and shown in their Fig. 1, was designed by me See Figs. 3 and 4 of Kaufman, et al., in their article in AIAA Journal, Vol. 15 (1977), beginning on p. 843 - copy attached). The description of the anode construction and Fig. 1 of Ceasar, et al., are sufficient to limit the source to either the 10 cm source or the 20 cm source shown in the above-mentioned Figs. 3 and 4 in the Kaufman, et al., article, both of which I designed. Although the specification of Ceasar, et al., implies only a single ion source was used (col. 5, lines 36-55), Fig. 2 shows a different ion

source than Fig. 1, with the source in Fig. 2 closer to the design shown in Fig. 1 of the article by Isaacson, et al., in *Journal of Spacecraft and Rockets*, Vol. 14 (1977), beginning on p. 469 or the similar design shown in Fig. 2. of the article by Kaufman in *Journal of Vacuum Science and Technology*, Vol. 15 (1977), beginning on p. 272. Regardless of which type of ion source was used by Ceasar, et al., I am very familiar with these and similar ion sources that use electrostatic acceleration for the ions, and neither would be capable of operating with ion energies of 50 eV or less, due to an instability that is found when the beam supply voltage approaches the discharge voltage. Those only moderately skilled in ion source art are unfamiliar with the inability of these ion sources to operate at very low ion energies, because they have been interested only in the practical limit, which is the ability to generate a useful ion beam current and is at several hundred eV or more, depending on details of the ion optics construction. The practical limit is the one given by Harper in the aforementioned chapter. The ion current capacity of these ion sources varies as the 3/2 power of the voltages used, which means that the ion beam current drops drastically as the voltages are decreased. Again, the ion source or sources of Ceasar, et al., won't operate at ion energies of 50 eV or less - and they won't generate useful ion currents unless the ion energies are much higher.

10. The only ion source other than the Kaufman source mentioned by King is the duoplasmatron (col. 5, line 41). The

above cited chapter by Harper also describes the duoplasmatron. Because the duoplasmatron uses single-aperture ion optics, compared with the hundreds or thousands of apertures in the Kaufman source, even higher ion energies are required for useful ion current - "at about 20 keV" according to Harper (p. 182), which is consistent with the "typically 20 keV" given by King (col. 7, lines 35-42). The duoplasmatron is thus even further removed from operation at 50 eV or less than is the Kaufman source.

11. The King patent (col. 5, lines 32-37) describes the useful energy range for the beam of ions as "0.5-50 keV." Although mentioned at col. 4, lines 58-60, that a threshold sputtering energy may be 20-30 eV, he goes on to say "but removal of significant amount of surface material (i.e. yields approaching 1 atom/ion) are not usually achieved until incoming energies are in the order of 100's of eV's." Further, King is referring to deposition on substrate 5, not sputtering from target 4, in lines 58-60. King therefore teaches one of ordinary skill in the field that there is no practical operation at an ion beam energy of 50 eV or less.

12. The Fu, et al., patent does not pertain to an ion beam source. It relates to a direct-current diode, without an ion source operating at a pressure substantially higher than the surrounding volume, and it does not produce an ion beam directed at the target. Although Fu, et al., does mention a negative bias, this is because a direct-current diode requires a negative

target bias.

13. Sputtering without a target bias is the normal way to sputter with a directed ion beam, but a direct-current diode will not work at all without a target bias. Thus the Fu, et al., patent refers to a fundamentally different art than sputtering by directed ion beams.

14. Fu, et al., shows concave and convex targets, but in the field of direct-current diodes, which, as described above, is a field that is fundamentally different than the field concerned with sputtering by directed ion beams. The purpose of a shape for the target surface in Fu, et al., is to eliminate redeposition on the target sidewall (col. 2, lines 62-64), while in the present invention the shaping is for the purpose of controlling the trajectories of the secondary electrons that are emitted from the target surface (see p. 17, lines 1-13).

15. Ceasar, et al., clearly do not teach or suggest a magnetic field located near the sputter target. The Pinarbasi patent repeats the well known teaching that a magnetic field within the discharge chamber increases the efficiency of operation. This does not suggest or teach the use of a magnetic field in front of a target for containing secondary electrons.

16. In Quasi, there is mention of a radiofrequency bias in a "RF glow discharge" (also known as a RF diode). The Quasi reference does not suggest operation in an apparatus for sputtering with a low energy directed ion beam (which is required in this invention). Further, Quasi requires much higher gas

pressure than used in the present invention.

17. Regarding the Arnold reference, it does show a "dark space shield" in "cathode sputtering", also known as diode sputtering. The Arnold reference does not teach the use of a low energy ion source as required in this invention.

18. The *Ion Beam Neutralization* technical disclosure does refer to an end-Hall type of gridless ion source and a hollow cathode source. However, such teaching does not suggest that it would have been obvious to use an end-Hall ion source in the apparatus of Ceasar, et al. The Ceasar, et al., patent describes the need to confine almost all of the ion beam to the target (see col. 7, lines 42-52). This is contrary to the present invention.

19. Combination of the teachings of the cited references would not lead to the present invention because they do not teach that a very low energy ion beam can be used in a manner that the present application describes to obtain deposited films without contamination. As to the use of a hollow cathode, with or without an end-Hall ion source, there is no teaching regarding ion energy in the publication *Ion Beam Neutralization*. Inasmuch as a low energy is required for the present invention, the cited publications have no relevance.

20. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or

imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 25 November 2002



Harold R. Kaufman